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Gambling with Global Warming

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Modern climate change is the result of the most wide-reaching market failure in history. But the proper response to that failure is not to abandon the market and directly regulate our impact on the climate system. Nor is it to continue to "muddle through" the policy problems arising from the climate change debate, applying a patchwork of responses that end up overlapping, conflicting, and wasting resources. Rather, society and government must create ways to make the market work—allocating scarce resources in a flexible, decentralized manner, allowing self-interest to determine the most efficient way to create social good and minimize social harm.

Yale economist William D. Nordhaus has devoted much of his career to studying the human costs implicit in climate predictions and in the policies designed to control them. In his new book *The Climate Casino*, Nordhaus argues that there are only two economically defensible policies to address the impacts of global warming: cap-and-trade schemes and a carbon tax. But before explaining and defending them, he takes the reader on a whirlwind tour of industrial economics, climate science, modeling and forecasting, impact assessment, and strategy choice. He concludes by reviewing obstacles to enlightened policy. Most books on climate change are penned by journalists and advocates. A few are written by experts in the sciences. Fewer still are by economists, and none come from scholars as central to the study of climate change policy as Nordhaus has been for the last forty years.

A Balancing Act

Nordhaus is mostly in the business of informing rather than persuading. Without being overly technical, he draws the reader into the nuts and bolts of climate policy formation and its precursors, while relegating advanced material to footnotes and references. He is at pains to point out the flaws in climate communication by the right and the left alike—which is part of why he seems to have had trouble making friends on either side. Environmentalists on the left think of him as an appeaser, giving

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aid and comfort to the enemy, while climate skeptics have their doubts about anyone who accepts the findings of mainstream climate science, as Nordhaus clearly does. But he has earned grudging respect from some climate-change deniers: "not obviously a crackpot" is how one critic of climate science described Nordhaus, to distinguish him from more strident advocates. Indeed, Nordhaus himself is worried that skeptics have mistakenly taken solace in his previous work, and he dedicates part of one chapter of his new book to explaining how he's been misinterpreted, and why the skeptics are wrong, repeating arguments he originally made in a 2012 article in the *New York Review of Books*.

Environmentalists, meanwhile, consider him a dangerous moderate for advocating a strong yet gradual approach to restricting emissions (a "ramped" policy) and for paying attention to the costs of combating climate change, including the ways that climate policy could harm economic growth. When noted economist Nicholas Stern authored a British government report calling for rapid and drastic climate action, Nordhaus dissented. For example, Nordhaus noted that Stern's calculations use an almost zero rate of real return on capital—an assumption that Nordhaus calls "a prescriptive approach," as it is based on an ethical assumption that the interests of future generations should count as much as the interests of the current generation. Nordhaus argues for a descriptive approach, which values the costs of climate mitigation strategies in terms of lost future wealth, making action on climate change compete with other investments that society could make.

In similar fashion, Nordhaus steadfastly maintains that the main number animating climate advocates in recent years—a commitment to avoiding warming the planet by more than two degrees Celsius—is an arbitrary and quixotic obsession, and that economic rationality demands that we tolerate a larger change. Using the tools of cost-benefit analysis, he explains why the two-degree target is likely to be unattainable except at very great cost to society. Realistically, participation in a climate policy regime will be less than global, and even among those who do participate, policies will be implemented imperfectly, making it unlikely that warming can be limited to two degrees. Nordhaus recommends instead a target limit of three degrees. This will frustrate environmentalists who have

The Climate Casino: Risk, Uncertainty, and Economics for a Warming World
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rallied around the lower figure. But avoiding ideology, making assumptions explicit, and using all available information are the hallmarks of Nordhaus's analysis.

Nordhaus's worldview is anthropocentric, his approach utilitarian. He worries not about moral concerns over climate change itself but about its tangible costs to systems and activities that support human well-being. Defending the legitimacy of an economist writing a book on what's often depicted as a purely scientific issue, he writes,

> Clearly, we cannot hope to understand the problems of warming without studying the basic findings of earth scientists. But global warming begins and ends with human activities.... Our policies must be well grounded scientifically. But the best science in the world will not by itself change the way people spend their incomes or heat their homes.

Nordhaus balances costs and benefits to people, not to other creatures. He explains in detail some of the impacts of climate change upon natural systems, but he shows agnosticism about how to value those damages (and therefore how to include them in his analysis).

Throughout the book, Nordhaus reminds us that the interplay between the climate system and the economic system is far too complex for mere intuition to be a faithful guide to policy. To understand the world as it is requires the use of models to clarify what is important and what is not. His models and data sets are public, downloadable from his website. With them he assesses the costs and benefits of various warming targets. And the impacts to human welfare he examines are wide-ranging. He usefully separates his analysis into two groups: managed systems, such as agriculture, manufacturing, and health care, and unmanaged systems, such as oceans, hurricanes, and wildlife. In managed systems, humans are the drivers, controlling the consumption of resources; in unmanaged systems, we're more like passengers. In managed systems, climate impacts can be substantially abated or avoided through human intervention, entailing some cost, while unmanaged systems are less responsive to our interventions, and can wreak havoc on economies.

Tipping Points

Climate models aren't truth machines or fortune-telling devices. They involve a lot of uncertainty. Some kinds of uncertainty—known unknowns—are built into the models because they're part of the questions being asked: a range of future trajectories of carbon dioxide

emissions from economic activities can be used as input to project a range of climate impacts and suggested responses. Slightly more warming will make these impacts slightly more severe; less warming slightly less. Events may turn out better or worse than we expect, but we can begin to estimate their costs; it's classic fodder for traditional risk analysis. Nordhaus claims that the most serious concerns are those impacts of which we are most ignorant and which do not lend themselves to classic calculations of risk—those that could lead to runaway changes when they reach a tipping point.

A tipping point is a threshold beyond which damage rapidly worsens and becomes far more difficult to reverse. These points are much conjectured about but little understood. Nordhaus takes them seriously and constantly reminds the reader of their potential. They're one of the most alarming aspects of reasoning about climate change, not least because they could suddenly render moot the kind of careful analysis Nordhaus is undertaking, based as it is on assumptions of steady marginal benefits and costs. Though he shows how the recognition of tipping points can slightly alter climate targets, he forces us to see the severe information constraints we have to work with. Nordhaus admits the true fear of climate change researchers: not that greenhouse gas emissions slowly warm the planet to dangerous levels—which they will, without intervention—but that the climate system may cross some threshold beyond which it will lose its stability. Tipping points are a grave concern, and studying them requires grappling with immense uncertainties.

Anyone who has traveled by canoe knows something about tipping points. A canoe is actually a fairly stable system, within limits. Try to gently tip it and it rights itself. The stability comes from negative feedback: the side that dips down displaces more water and is forced up, and the elevated side is pulled down by gravity. Continue to lean and the canoe tilts, but you can right it by leaning back. It feels tippy, but it doesn't actually tip, and you can get accustomed to the feel. The reversibility of the system is useful, since you can lean out to paddle around obstacles and make tight turns. But lean too far and you begin to leave the domain of stability and enter the realm of positive feedback: the canoe tips dangerously, your body weight falls in the same direction, tilting the canoe even more, until the gunwale goes under the water. Go past the tipping point, and you're swamped, maybe sunk. Sadly, a swamped canoe is, technically, more stable than a dry canoe. Once swamped, a canoe tends to stay swamped, which is another way of saying you've entered a new, wetter, and less desirable stability domain. Importantly, exceeding the threshold

cannot be simply reversed. Scientists call it *hysteresis* when the return path to the initial stable state involves different mechanisms than the original tipping. Unswamping a canoe involves a lot more effort, and very different methods, than keeping it afloat.

The earth's climate system has a mixture of negative feedback and positive feedback mechanisms. Plants grow more rapidly when atmospheric carbon dioxide levels are higher, and so soak up some of the extra carbon—a negative feedback. Negative feedbacks give us a discount on our global warming pollution, and quantifying them is a key to global climate models. Positive feedbacks amplify climate change; they're destabilizing forces. Whereas arctic sea ice reflects most sunlight back into space, open seas absorb solar energy and become warmer. The balance between sea ice and open water determines the portion of solar energy reflected or absorbed over water surfaces. As warming reduces sea ice, more solar energy is absorbed, leading to warmer seas, which melts more sea ice—a vicious cycle. Conversely, if sea ice coverage happened to increase, more solar energy would be reflected, cooling the seas and creating still more ice. Cooling begets cooling, and warming begets warming. Positive feedbacks are more likely to lead to tipping points.

As greenhouse gas emissions grow and climate change hastens, which kinds of feedback will predominate? Both will continue to operate, but their relative contributions may change. For example, the fertilization effect of carbon dioxide on plant growth could lessen at higher temperatures, reducing the strength of that stabilizing mechanism. And new positive feedbacks may kick in at higher temperatures. As permafrost melts and begins to decompose, it releases carbon dioxide and methane, both greenhouse gases. A similar process occurs as oceans warm and release frozen methane from deep, cold sediments. Of course, there's an upper limit to the amount of methane stored in permafrost and the oceans, and eventually its decomposition will slow and halt. Other tipping points that concern Nordhaus are the collapse of large land-based ice sheets in Greenland and West Antarctica, leading to dramatic sea level rise, and the potential for the collapse of the Gulf Stream, leading to rapid climate change, especially in the North Atlantic region.

The science on tipping points is in its infancy, but the possibility of swift, dangerous change has to be considered in policy formation. Two features of tipping points concern Nordhaus the most. First, they have multiple equilibria—points at which they could stabilize—some of which would be damaging to human welfare and difficult to reverse. Second, as with financial tipping points like bank runs, they may "take much longer

to arrive than you think, and then they happen much faster than you could imagine."

The task of modelers is to try to understand the balance between these various stabilizing and destabilizing forces. But the problem for Nordhaus is unpredictability: we just don't know how stable the canoe is. While most of the models Nordhaus uses are mathematical—an encapsulation of empirical relationships on the biophysical side and common sense on the social side—the possibility of tipping points leads him from a quantitative model to a metaphorical one: by adding unmitigated global warming pollutants like carbon dioxide to the atmosphere, we are entering the titular Climate Casino, by which Nordhaus means that "economic growth is producing unintended but perilous changes in the climate and earth systems." Spinning the climate roulette wheel is a gamble, and there are wins and losses.

Based on what we already know, Nordhaus is sure that we should back away from that roulette table—it's a losing proposition when expected climate impacts are set against the social benefits of burning fossil fuel. Worse yet, lurking on the wheel are a few worrying pockets of low probability but high loss. We don't know how many there are and how costly it would be to land on them. That uncertainty is enough for Nordhaus to recommend we strongly mitigate greenhouse gases. "We are rolling the climatic dice, the outcome will produce surprises, and some of them are likely to be perilous." While the findings of climate science, and the policy prescriptions that follow from them, "must be qualified and constantly updated because of the uncertainties involved," Nordhaus concludes that "the balance of risks indicates that immediate action be taken to slow and eventually halt emissions" of carbon dioxide and other greenhouse gases.

Solutions That Use Markets and Incentives

From the point of view of economic theory, there's nothing mysterious about global warming pollution. Human-induced climate change is a classic externality—a side effect of productive economic activity that does not enter into the calculus of decision-makers. Since emitting carbon dioxide is free and its impacts fall mostly on third parties, no utility-maximizing individual or profit-maximizing business would try to control its emissions, even if the emissions cause great harm to others. The basic problem, as Nordhaus understands it, "is that those who produce the emissions do not pay for that privilege, and those who are harmed are not compensated." Because they consider only the costs to themselves and not

to society, firms produce too much pollution. The same narrowly rational mindset afflicts nations: what country would impose costly restrictions on its global warming emissions if the benefits of restricting them go mostly to other countries? Only mutual coercion mutually agreed upon, in the phrase of ecologist Garrett Hardin, would cause nations to slow their emissions.

But simply showing that carbon emissions constitute an externality is not enough to justify massive government intervention to implement the kind of coercion needed to limit emissions. As Ronald Coase pointed out in his classic 1960 paper "The Problem of Social Cost," a certain class of externality can be solved without the strong hand of a central state. In his example, a rancher's cows stray onto a farmer's field, damaging crops—a clear, straightforward externality. Land and property rights will determine whether the rancher is liable for the damage, and self-interest will determine who would build a fence to prevent future damage and liability, assuming the fence costs less than the likely future damage to crops. If the fence costs more than the damage, other solutions are possible, like one party compensating the other, or one or the other changing its business model. The economic actors, with well-specified property rights, could negotiate a solution, and, assuming the absence of high transaction costs (like legal fees, monitoring, or intimidation), they would arrive at a socially optimal level of damage, compensation, and prevention. The Coase theorem, as it came to be known, showed that economic efficiency could be achieved through private action.

The major results of this thought experiment are counterintuitive but compelling. First, for private actors to find the socially optimal level of an externality, government need only specify property rights well, allow those rights to be traded, and enforce contracts. Heavy-handed and inefficient regulation is unnecessary and unhelpful. Second, the optimal level of a negative externality—such as crop damage or air pollution—is usually not zero. In other words, it's often better to allow for some limited forms of damage as a cost of doing business, rather than incur the higher costs of preventing that damage completely. Laws that aim to prevent pollution may be economically inefficient, if the impacted parties would be willing to suffer some harm in exchange for compensation. Free-market environmentalists make much of these results, and suggest that many environmental regulations are inefficient.

But there's no straightforward Coasian solution to global warming pollution. The fact that carbon dioxide and other greenhouse gases are global and not local pollutants makes transaction costs high. A polluter

would have to strike a deal with every impacted enterprise on the planet. Moreover, greenhouse gases can stay in the atmosphere for decades or even centuries, and it is difficult to make voluntary bargains with future generations. Enforcing contracts would require extensive policing and monitoring, and an enormous court system to adjudicate disputes. The Coasian solution applies most aptly to externalities that are visible, direct, and immediate. Carbon pollution has none of those properties.

But might there be other solutions that permit the externalities of greenhouse gas emissions to be dealt with as quantifiable damages? That's exactly what Nordhaus and his fellow economists attempt to do. They try to consider what would happen if a perfect market existed in which the external costs of pollution were paid by polluters, who were then free to decide how much pollution to emit based on their private calculus. These economists create models of such a market, using available data on the costs and benefits of polluting, to arrive at an educated guess on the optimal price at which greenhouse emissions would be traded, and the optimal level of those emissions. This optimal level reflects the point at which increased reduction in damages is not worth the additional cost of abatements. While this point is hard to establish exactly, it is clear, Nordhaus explains, that "good policies must lie somewhere between wrecking the economy and wrecking the world."

With models of an emission market in place, there are two roughly equivalent directions economic policy could go, as Nordhaus describes. Armed with a prediction of the optimal level of emissions, a government could create a system of permits to distribute the right to pollute among polluters, and then allow emitters to pay for and trade those permits—the "cap-and-trade" system. The freedom to trade the permits creates incentives for companies to reduce their emissions, since they must pay more as they emit more, while they can sell their permits if they reduce their emissions below their permit levels. Having set an optimal quantity of pollution, the government would allow the market to determine the price of pollution permits. In the consumer market, goods made using processes that require more greenhouse emissions will be more expensive, and consumers will begin to prefer goods that require less pollution to make. The result is that actors operating in their private interests arrive at the social good of reducing emissions as cheaply as possible. This system, once promoted by conservative policy wonks, works well in controlling sulfur dioxide pollution in the United States, and has been proposed for mercury pollution as well. An international cap-and-trade system for carbon has been in place in Europe for nearly a decade but is now near collapse,

a perfect example of the imperfect execution of policies that Nordhaus warns about.

A similar, alternative proposal would have the government impose a tax on greenhouse gases like carbon dioxide. This would be an example of a "Pigovian" tax—named for the economist Arthur Pigou, who in 1920 first proposed the idea of fixing missing or broken markets by charging a tax equivalent at the margin to the social costs of an externality. Assuming that the tax level is set appropriately, such a system would force businesses and ultimately consumers to consider all true costs. In the case of a carbon tax, consumers would pay the full social cost of the goods they consume, and would make decisions freely about which goods are worth the extra price.

Nordhaus argues that these two systems, cap-and-trade and carbon taxation, "are fundamentally the same." They are both methods of creating incentives for consumers and firms to reduce emissions by raising the price of emitting. Both policies call for a central government authority to address a failure of the market. One calls for the government to estimate the socially optimal level of pollution and set a cap; the other calls for the government to estimate the damage and mitigation costs of global warming, and impose those costs on those who are doing the damage. But Nordhaus believes a carbon tax would be more palatable to conservatives, as it would improve economic efficiency by correcting for the fact that without any such tax, producers with high carbon emissions are in effect using a shared good without paying for it. In fact, a carbon tax is "an ideal policy for true conservatives who care about preserving our beautiful planet but want to do so with well-tuned economic incentives and with minimal government intrusion into people's lives and business decisions."

Technical Solutions and Moral Hazards

Besides these economic reforms, another prospect for addressing climate change is geoengineering—the use of technological innovations to combat warming—which could serve either to complement or undermine emission reductions, depending on one's view. From one perspective, a global agreement on greenhouse emissions, with widespread participation and efficient implementation, is a tall order for the family of nations, so we ought at least to conduct research on geoengineering as a second-best solution, to better understand how to wield that power in case the climate begins to spin out of control.

But while reaching a truly global agreement on how to control inadvertent warming is fraught with difficulty, the challenges of managing intentional climate change will be clear to anyone working in an office building with a shared thermostat. Who will control the setting? Not everyone will agree, and almost every geoengineering technology will have global and unexpected impacts. Pumping particles into the atmosphere to reflect solar radiation, or fertilizing the ocean's phytoplankton with iron, may allow some control of global average temperatures, but the local effects on temperature, rainfall, and wind patterns will be disparate and unpredictable. Moreover, the fact that these schemes could be undertaken with moderate resources could tempt some rogue actor—a nation-state, a corporation, or some other private entity—into taking unilateral action, making the political dimensions of geoengineering difficult and possibly even dangerous.

Some critics of geoengineering point out that even basic research in this area is fraught with moral hazard: knowing that we might reverse warming with technology increases the likelihood that we'll ignore mitigation as a primary strategy. Others, by contrast, respond that more research is just as likely to reveal flaws in the geoengineering approach, thereby taking it off the table and making the moral hazard less likely. Nordhaus argues that the moral hazard is exaggerated, but that even if it exists, it is better to know what kind of rescue operation might be possible than to rely solely on our ability to stave off climate change through mitigation.

Technological innovation may also come to the rescue on the energy-production side of the equation. One of the main reasons Nordhaus cites for putting a price on carbon is to create incentives for private investment in low-carbon technologies. The efforts to restrain global emissions entail that most of the earth's remaining stores of oil, gas, and other fossil fuels will have to remain unused underground, forever. Without technological innovation, they will be a constant temptation to future generations hungry for cheap energy. Society needs for those fuels to be not just legally but practically undesirable. Our eventual goal must be for new technologies to make fossil fuels obsolete. This imperative will be all the stronger if global emission restrictions fail.

Predictions and Prudent Policy

Utopian ideas of restructuring society pervade progressives' policy discussions about climate change and the need for a "new energy economy."

But social engineering should not be the aim of climate policy. Income and wealth inequalities are troubling side effects of the operation of the free market, but climate policy must be aimed at climate change, not at social leveling. Likewise, climate policy should not be choosing winners and losers in the marketplace for technological innovation; there is too much room for special political interests to intrude in decision-making on which technology to implement. Climate policy need not, indeed must not, devolve into a free-for-all grab for power on the part of environmentalists, population-control advocates, corporate special interests, or government bureaucrats. That's why a carbon tax policy, as Nordhaus describes it, makes so much sense: it prescribes little except to finally make markets work properly, unleashing human ingenuity and self-interest in the service of human welfare.

If there is a flaw in Nordhaus's thinking, it is believing that the rate of economic growth since the end of the Industrial Revolution is normal and will continue indefinitely. Because he assumes that economic growth will make our descendants vastly more wealthy than us—just as we are vastly more wealthy than our grandparents and great-grandparents—his estimates of the costs of climate damage and mitigation are small as a proportion of economic production. This is a comforting thought, but those with a long view of history know something of its vicissitudes. We want to preserve the engines of growth that brought us modernity's material blessings, so that our descendants may be even more prosperous than us. But a more robust view of the future must consider the possibility that immiserating forces could prevail, so that future generations will live lives more exposed to the powers of nature than ours. We must bequeath to future generations both the economic capital and the natural stability they will need to flourish. Nordhaus's approach aims to discern the optimal balance between the two, but it is far from clear that he has found it.

Russell Kirk, in his book *The Politics of Prudence*, listed prudence—the ability to judge political actions by their long-term effects—as one of the principles that marks a conservative worldview: "Sudden and slashing reforms are as perilous as sudden and slashing surgery." This principle holds true for policy in response to climate change. Nordhaus's recommended response to the increasingly urgent impact is not to radically overturn the world order, or slam the brakes on fossil-fuel use, but to apply steady and increasing pressure on carbon emissions by pricing them according to their true costs—avoiding the extremes of "wrecking the economy" by striving to eliminate all damages from carbon emissions and "wrecking the world" by doing nothing to avoid them.

What passes for climate conversation in the media and among the chattering classes is rarely elevated above bar talk—ideology sprinkled with factoids and emotion, delivered at high volume. Few admit of uncertainty or the legitimacy of opposing arguments; not many confess to self-doubt or bow to the validity of expertise that does not jibe with preexisting commitments. The rigor and breadth of Nordhaus's work should be sobering to those on the right and the left. It reveals that, although much has already been learned, we are still dangerously ignorant of the odds in the climate casino, and the time has come to start placing some smarter bets.